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(54) Title: METHOD AND SYSTEM FOR COMMUNICATION OVER MULTIPLE CHANNELS IN A SPREAD SPECTRUM COMMUNICATION SYSTEM
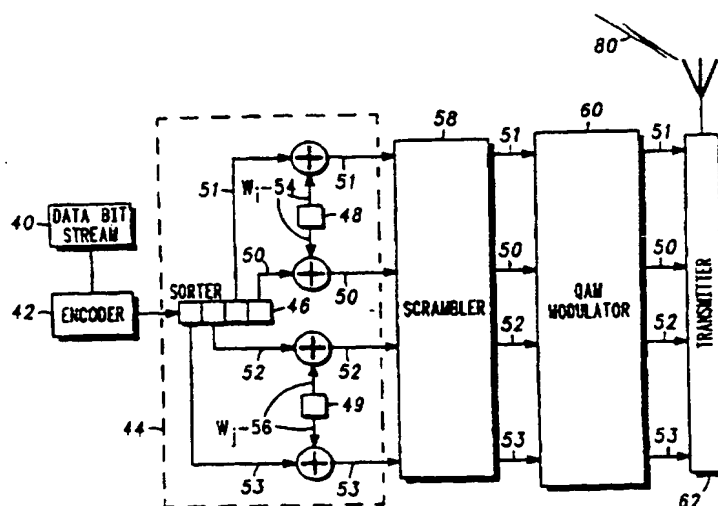
(57) Abstract

A method for transmitting a communication signal (20) having a data rate over a plurality of spread spectrum traffic channels includes determining a first number of traffic channels required to transmit the communication signal at the data rate, and determining a second number of traffic channels (502) available for transmitting the communication signal (20). In response to a comparison of the first number of traffic to the second number of traffic channels, a first traffic channel (54) for transmitting a first portion of the communication signal (50, 51) and a second traffic channel (56) for transmitting a second portion of the communication signal (52, 53) are selected from the second number of traffic channels (502). The selection of the first traffic channel (54) is non deterministic of the selection of the second traffic channel (56).

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Walsh covers serve as forward communication channel identifiers in the IS-95 system, each Walsh cover generally representing one communication channel. A Walsh cover corresponds to a single row or column of a

5    Hadamard matrix, a square matrix of chips (i.e., bits) with a dimension that is always a power of two. A Hadamard matrix **30** including 4 rows W0-W3 **100-103** and 4 columns **200-203** is shown in FIG. 1, each row W0-W4 **100-103** and column **200-203** representing a 4-chip Walsh

10   cover. A Hadamard matrix comprising the Walsh covers used in IS-95 (not shown) is a 64-by-64 matrix having rows W0 through W63. A detailed discussion of Hadamard matrices is given in John G. Proakis, <u>Digital</u> <u>Communications</u>, 1st Ed., p. 249 (1983), incorporated

15   herein by reference.

        Prior to transmission of a communication signal over an IS-95 forward channel, the communication signal is encoded, interleaved, scrambled by a pseudorandom noise (PN) code, bi-phase shift key (BPSK) modulated

20   with a 64-chip Walsh cover identifying the particular forward channel used for transmission of the signal, and quadrature phase shift key (QPSK) modulated into composite I and Q components by a pair of PN codes with an assigned time offset.

25       A transmitted communication signal which has been modulated with a 64-chip Walsh cover serving as a channel identifier may be demodulated by a conventional receiver which correlates a received signal with the particular Walsh cover used to modulate the

30   communication signal. This correlation is generally known to those skilled in the art, and comprises adding or subtracting bits of the Walsh cover according to an algorithm which is dependent on the particular Walsh cover used for modulation of the communication signal.

35   Thus, for each 64-chip Walsh cover, 63 complex additions

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are typically performed to demodulate one communication
signal bit.

It has been proposed in the art to allow for
variable rate signal transmission in a spread spectrum
5   communication system.  For example, U.S. Patent No.
5,471,497 to Zehavi ("Zehavi") describes, among other
things, an apparatus and method for communication of
information at data rates higher than 9600 bits per
second over communication channels in a CDMA system.

10      Zehavi discloses using orthogonal coset code sets,
i.e., rows of a Hadamard matrix, in conjunction with a
Walsh cover generator to assign an initial coset code
and a Walsh cover W (i.e., an initial channel) to a
first pair of information substreams.  Subsequent pairs

15  of information substreams (i.e., channels) are
identified by coset codes and the Walsh cover W, the
subsequent coset codes having a predetermined
relationships with respect to the first assigned coset
code.     A receiver digitizes a received signal and,

20  among other things, demodulates the signal to retrieve
the original  information substreams.  Estimates of the
information bits in each information substream are
obtained by performing correlations based on the
orthogonal coset codes and Walsh cover W used to encode

25  the input symbol streams.

After Walsh cover correlation is performed, the
resulting coset-coded data is converted from a serial to
parallel format and is input to a Fast Hadamard
Transform (FHT) having a number inputs equal to a number

30  of original information substreams.  The number of
inputs to the FHT is also equal to a number of rows and
columns of elements in the FHT.  A detailed discussion
of Hadamard transforms is provided in Ernest L. Hall,
Computer Image Processing and Recognition, Chapter 3,

sec. 3.3.3, pp. 138-143 (1979), incorporated herein by
reference.

    This method of channel assignment for a high data
rate communication described above results in the

5    assignment of a number of coset codes and a Walsh cover
to a user communication by a predetermined algorithm,
and generally eliminates a number of channels (i.e., a
number of Walsh covers) from being used by other user
communications simultaneously.  Thus, one or more

10   channels which may be needed for assignment to a new
user's communication being set-up according to a similar
predetermined algorithm may already be in use by the
communication system, and therefore not available for
assignment to the new user.

15    This problem is exacerbated during soft hand-off of
a call, when two base stations must each assign multiple
channels to the same communication signal.

    Thus, there is a need for a system and method for
assigning multiple traffic channels to a single high

20   data rate communication signal in a direct sequence
spread spectrum communication system where an identity
of one traffic channel used for the multiple channel
communication is not deterministic of an identity of
another traffic channel.

25    There is a further need for an efficient method for
demodulating a multiple channel communication where the
identity of one channel is not deterministic of an
identity of another channel.

30                **Summary of the Invention**

    According to an aspect of the present invention,
the foregoing problems are ameliorated by a method for
transmitting a communication signal having a data rate

35   over a plurality of spread spectrum traffic channels,

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which includes determining a first number of traffic
channels required to transmit the communication signal
at the data rate and determining a second number of
traffic channels available for transmitting the
5    communication signal. In response to a comparison of
the first number of traffic to the second number of
traffic channels, a first traffic channel for
transmitting a first portion of the communication signal
and a second traffic channel for transmitting a second
10   portion of the communication signal are selected from
the second number of traffic channels. The selection of
the first traffic channel is non deterministic of the
selection of the second traffic channel.

     In accordance with another aspect of the present
15   invention, a method for handing off a communication
signal in a spread spectrum communication system
includes transmitting the communication signal by a
first communication unit over a first group of traffic
channels and determining by a second communication unit
20   a number of traffic channels available for transmitting
the communication signal by the second communication
unit. When the number of traffic channels available for
transmitting the communication signal by the second
communication unit is greater than or equal to a number
25   of channels in the first group of traffic channels, the
communication signal is monitored by the second
communication unit over a second group of traffic
channels. The communication signal is then transmitted
by the second communication unit over the second group
30   of traffic channels.

     In accordance with a further aspect of the present
invention, a spread spectrum communication system
includes a first central communication unit responsive
to a mobile communication unit over a first plurality of
35   traffic channels and a first controller associated with

the first central communication unit operable for assigning a first group of traffic channels for transmitting and receiving a communication signal. The first group of traffic channels includes a first traffic

5   channel and a second traffic channel chosen from the first plurality of traffic channels. The first traffic channel is non deterministic of the second traffic channel.

In accordance with a still further embodiment of

10  the present invention, a method for receiving a modulated communication signal transmitted over a plurality of traffic channels in a spread spectrum communication system, each of the plurality of traffic channels being associated with a code having a plurality

15  of groups of chips, includes inputting the modulated communication signal to a decoder representative of a number of logical rows of adders and a number of logical columns of adders, the number of logical rows of adders and the number of logical columns of adders being larger

20  than a number of traffic channels in the plurality of traffic channels. The modulated communication signal is demodulated based on a first group of chips of a first code associated with at least one of the plurality of traffic channels, to form a first partially demodulated

25  communication signal, and demodulated based on a second group of chips of a second code associated with at least one of the plurality of traffic channels, to form a second partially demodulated communication signal. The first partially demodulated communication signal and the

30  second partially demodulated signal are combined.

Other advantages of the present invention will become readily apparent to those skilled in the art from the following description of the preferred embodiments of the invention which have been shown and described by

35  way of illustration. As will be realized, the invention

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is capable of other and different embodiments, and its
details are capable of modifications in various
respects.  Accordingly, the drawings and description are
to be regarded as illustrative in nature, and not as
5    restrictive.

## Brief Description of the Drawings

FIG. 1 is a Hadamard matrix including 4 rows and 4
10   columns, each row and column representing a 4-chip Walsh
cover.
FIG. 2 illustrates a block diagram of a forward
channel waveform design for a high data rate
communication signal in a DS-CDMA communication system
15   in accordance with a preferred embodiment of the present
invention.
FIG. 3 illustrates a block diagram of a receiver
for receiving a high data rate communication signal
transmitted over multiple DS-CDMA channels in accordance
20   with FIG. 2.
FIG. 4 is a conceptual drawing of a four-by-four
Hadamard decoder according to a preferred embodiment of
the present invention.
FIG. 5 diagrams a call flow for a high data rate
25   communication signal in a DS-CDMA communication system
according to a preferred embodiment of the present
invention.
FIG. 6 depicts a soft hand-off operation for a high
data rate communication signal in a DS-CDMA
30   communication system in accordance with the preferred
embodiment of the present invention.

## Detailed Description of the Preferred Embodiment

Turning now to the drawings, wherein like numerals
designate like components, FIG. 2 illustrates a block
diagram of a forward channel waveform design, such as
used in communication from an IS-95 base station to an
5    IS-95 mobile station, for a high data rate communication
signal in a DS-CDMA communication system.

A high data rate communication signal (not shown)
such as voice, data, video or a combination of these, is
converted to a data bit stream 40 (i.e., a series of
10   data bits), and is input to an encoder block 42 at a
rate higher than 9600 bits per second, for example,
38,400 bits per second. Using known methods, encoder
block 42 encodes data bit stream 40 at a fixed encoding
rate using algorithms which facilitate subsequent
15   decoding of the data symbols back into data bits.

Encoder block 42, which may further include an
interleaver (not shown), organizes the data symbols into
frames of a predetermined size according to conventional
methods. If desired, reference bits may be inserted
20   periodically within the interleaved data symbol stream
to further facilitate decoding of the data symbols.

The data symbols output from encoder block 42 are
prepared for transmission over multiple communication
channels by a modulator block 44. Within modulator
25   block 44, a sorter 46 demultiplexes the data symbols,
dividing the data symbols into data rails 50-53. As
shown, sorter 46 separates the data symbols into four
data rails 50-53, but a larger or smaller number of
data rails is possible, depending on the data rate of
30   the data bit stream 40.

Data rails 50-53 output from sorter 46 may be
divided into groups such as pairs. As shown, a first
pair of data rails 50-51 is bi-phase shift key (BPSK)
modulated with a first code such as a Walsh cover Wi 54
35   having length L, chosen from a list of available Walsh

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covers in the communication system, by a Walsh cover
generator **48**. The BPSK modulation may be performed
according to conventional methods.

Subsequent pairs of data rails may also be bi-phase
5    shift key modulated by different codes such as Walsh
covers having lengths L, also chosen from a list of
available Walsh covers in the communication system. An
identity of each Walsh cover chosen is preferably
independent of an identity of any previously chosen
10   Walsh cover. One way to ensure that the first Walsh
cover selected is non deterministic of the subsequently
chosen Walsh covers is to choose the covers arbitrarily
or randomly. As shown, data rails **52-53** are modulated
with Walsh cover Wj **56** by Walsh cover generator **49**.

15   This method channel assignment, where Walsh covers
for a high data rate communication signal are assigned
arbitrarily or randomly from a list of available Walsh
covers in the communication system, is an improvement
over algorithmic channel assignment methods. For
20   example, in an algorithmic channel assignment scheme,
one or more of the Walsh covers assigned to the
communication according to the algorithm may already be
in use by the communication system.

At scrambler blocks **58**, data rails **50-53** are all
25   scrambled by the same synchronized short pseudorandom
noise (PN) sequence according to well-known scrambling
techniques. Alternatively, individual inputs to
scrambler block **58** may not necessarily be acted on by
the same sequence. Data rails **50-53** are subsequently
30   input to a quadrature amplitude modulator (QAM) block
**60**, which utilizes a quadrature amplitude modulation
process such as quadrature phase shift key modulation or
another modulation process to modulate data rails **50-53**
according to well-known methods. Finally, transmitter
35   block **62** operates on data rails **50-53** by summing,

upsampling, transmit filtering, upbanding and broadcasting them to form a modulated communication signal **80** according to conventional methods.

FIG. 3 illustrates a block diagram of a receiver
5   for receiving a high data rate communication signal transmitted over multiple DS-CDMA traffic channels as described in connection with FIG. 2. After being received by antenna **72** and passing through filter **70**, modulated communication signal **80** is descrambled by
10  conventional methods at descrambler block **74**. Descrambler block **74** removes the scrambling sequence or sequences applied by scrambler block **58**. A descrambled communication signal Si **90** is input to fast demodulator block **76**. The descrambled communication signal Si **90**
15  may correspond to a pairwise summation of data rails **50,51** and data rails **52, 52**.

Fast demodulator block **76** demodulates descrambled communication signal **90** which, as shown, has been BPSK modulated with Walsh covers Wi **54** and Wj **56** (discussed
20  in connection with FIG. 2). Fast demodulator block **76**, which preferably includes a decoder **77** such as a Hadamard decoder having a fixed number of logical rows of adders equal to the length L of Walsh covers Wi **54** and Wj **56** and a fixed number of logical columns of
25  adders equal to logarithm base two of the length L of Walsh covers Wi **54** and Wj **56**, utilizes a correlation algorithm which jointly demodulates Walsh cover Wi **54** and Wj **56** using partial sums (discussed below).

A Hadamard decoder may be implemented using
30  commercially available hardware as an array of adders or as a multiplexed adder, depending on the dimension of the decoder. For example, for a decoder of small dimension, an array of adders may be used, so that the number of rows of adders in the array is equal to the
35  length of the Walsh covers to be decoded. For a large

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decoder, however, a multiplexed adder may be designed, so that the multiplexed adder is merely representative of the number of logical rows equal to the length of the Walsh covers to be decoded.

5        Alternatively, a Hadamard decoder may be implemented within a receiver utilizing a conventional digital signal processor (DSP) such as Motorola part no. 56166. The DSP, working in conjunction with a computer-readable memory storing an array of data points

10     logically representing the rows and columns of adder outputs, performs specific additions according to a predetermined method for calculating partial sums (examples of partial sum caluculations are discussed below).

15     A conceptual drawing of a four-by-four Hadamard decoder **77** is shown in FIG. 4. As shown, logical representations of rows and columns of adders **450** are available to simultaneously demodulate a signal (not shown) appearing at input paths **800-803**. The signal

20     appearing at input paths **800-803** represents one, two, three or four data streams, each data stream represented including data symbols having been BPSK modulated by one of four Walsh covers of four chips in length (discussed in connection with FIG. 1). Outputs **900-903** may be

25     elements in a demodulated data stream, or noise.

        For example, referring to FIG. 1, if Walsh cover W0 **100** was assigned to modulate the signal appearing at input paths **800-803** shown in FIG. 4 and no other Walsh codes were assigned (i.e., the signal represents only

30     one data stream), then output **900** represents a data symbol in the demodulated data stream at each sampling time, and outputs **901-903** are noise. On the other hand, if Walsh covers W0-W2 **100-102** (depicted in FIG. 1) were assigned to modulate the signal appearing at

35     input paths **800-803** shown in FIG. 4 (i.e., the signal

represents three data streams), then outputs 900-902 represent data symbols in demodulated data streams at each sampling time, and output 903 is noise.

By utilizing partial sums, the number of complex
5   additions required (that is, the number of adders turned "on" in the Hadamard decoder) to recover each data symbol is minimized. Reducing the number of complex additions performed results in decoder current drain being reduced. The correlation algorithm, and hence the
10   number of complex additions or adders utilized to recover each data symbol, is determined by the identities of the particular Walsh covers used to modulate the signal, such as spread communication signal 80, shown in FIG. 3.

15      Still referring to FIG. 3, consider a first example of partial sum demodulation by a Hadamard decoder. Suppose that Wi 54 is W0, a 64-chip Walsh cover represented by 64 zeroes, and that Wj 56 is W1, a 64-chip Walsh cover where even chips are zeroes and odd
20   chips are ones. Partial sums $S_0$ and $S_1$ may be formed by fast demodulator 76 using descrambled communication signal Si 90 as follows:

$$S_0 = \sum_{i=0,even}^{62} S_i$$
$$S_1 = \sum_{i=1,odd}^{63} S_i$$

25

Then, $S_0$ and $S_1$ are combined to give an output $D_0$ 78 corresponding to one data symbol BPSK modulated by Wi 54 and an output bit $D_1$ 82 corresponding to one data symbol BPSK modulated by Wj 56 as follows:

30

$$D_0 = S_0 + S_1$$
$$D_1 = S_0 - S_1$$

As a result of using partial sums $S_0$ and $S_1$, the number of complex additions per output data symbol **78**, **82** is 32 rather than the 63 required for a conventional IS-95 demodulation operation.

5      To recover initial data bit stream **40**, outputs **78**, **82** are deinterleaved and decoded at block **92** according to conventional methods.

In a second example, suppose that W0, W13 and W45 of a 64-by-64 Hadamard matrix are the assigned Walsh

10    covers for a high data rate communication. As is known, W45 has a complicated pattern of 1's and 0's. Let b be the 4 bit sequence {0, 1, 0, 1}, and B = {1, 0, 1, 0}. Then W45 = bBBbbBBbBbbBBbbB, where juxtaposition of these sequence variables creates a concatenated

15    sequence. Thus, the 64 bit sequence consists of 16 4-bit sequences.

There are two ways to operate the fast demodulator **76** for this example. According to a first method, data symbols modulated by W0 and W13 may be demodulated as

20    described in connection with the first example, and W45 may be despread conventionally. Then the total number of complex additions would be 2*32+63, or 127. Thus, to retrieve each output data symbol would require approximately 43 complex additions.

25    According to a second method, a first step results in 2*16 additions being performed as follows:

Thirty-two (32) partial sums are formed to exploit short term correlations of the following patterns:

$$S_{j,45,even} = s_{2j+0} + s_{2j+2}; j = 0,2,4,...30$$

30    $$S_{j,45,odd} = s_{2j+1} + s_{2j+3}; j = 0,2,4,...30$$

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In a second step, the partial sums from the first example are recovered resulting in 2*15 additions as follows:

$$S_0 = \sum_{i=0,even}^{32} S_{j,45,even}$$
$$S_1 = \sum_{i=0,even}^{32} S_{j,45,odd}$$

A third step resulting in 2*1 additions is performed as follows:

$$D_0 = S_0 + S_1$$
$$D_1 = S_0 - S_1$$

Finally, a fourth and final step producing 31 additions is performed as follows:

$$D_{45} = S_{0,45,even} - S_{0,45,odd} - (S_{2,45,even} - S_{2,45,odd})$$
$$-(S_{4,45,even} - S_{4,45,odd}) + (S_{6,45,even} - S_{6,45,odd})$$
$$+(S_{8,45,even} - S_{8,45,odd}) - (S_{10,45,even} - S_{10,45,odd})$$
$$-(S_{12,45,even} - S_{12,45,odd}) + (S_{14,45,even} - S_{14,45,odd})$$
$$-(S_{16,45,even} - S_{16,45,odd}) + (S_{18,45,even} - S_{18,45,odd})$$
$$+(S_{20,45,even} - S_{20,45,odd}) - (S_{22,45,even} - S_{22,45,odd})$$
$$-(S_{24,45,even} - S_{24,45,odd}) + (S_{26,45,even} - S_{26,45,odd})$$
$$+(S_{28,45,even} - S_{28,45,odd}) - (S_{30,45,even} - S_{30,45,odd})$$

Thus, a total number of additions required for the second method is 95, or approximately 32 additions per output data symbol.

As a third example, suppose that W0, W1, W45 and W2 are used to modulate a high data rate communication signal. In this case, examples one and two may be used to jointly demodulate W0 and W2, while doing a separate

joint demodulation of W1 and W45.   Again, the number of
complex additions would be reduced from 63 to about 32.

In a fourth example, assume that W0, W1 and W2 are
used to modulate a high data rate communication signal.

5   There are no partial sums or subpatterns shared between
these three Walsh covers.   One possible solution is to
demodulate W0 and W1 according to the method of the
first example, and to demodulate W2 conventionally.
Then a total number of additions would be 64 + 63, or

10   about 40 complex additions per output data symbol.   Even
for this poor choice of Walsh covers, the additions
required per output has been reduced from 63 required by
the conventional method of Walsh cover demodulation, to
approximately 40.

15   As will be appreciated by one skilled in the art, a
receiver having multiple receiving portions such as a
well-known RAKE receiver may be used to achieve space
diversity.   In addition, it will be understood that RAKE
receiver fingers performing searching functions as well

20   as early and late timing functions in accordance with
the principles of the present invention will facilitate
demodulation of all of the data symbols for the various
Walsh covers.

FIG. 5 diagrams a call flow for a high data rate

25   communication signal in a DS-CDMA communication system
according to the preferred embodiment of the present
invention.   Upon receiving a request for a communication
having a high data rate at block 400 from a
communication unit such as a mobile station (not shown),

30   a communication unit such as a base station or a central
communication unit (not shown) calculates a number of
traffic channels required to transmit the communication
signal at the requested data rate at block 404.

If it is determined at block 406 that the required

35   number of traffic channels is available within the

communication system, the base station may select the
channels for transmitting the communication signal from
a list of the available channels at block 408. If
desired, channel selection may be performed in an

5    arbitrary fashion from the list of available channels.
If the required number of traffic channels is not
available within the communication system, the data rate
of the communication signal is modified, for example,
lowered, at block 410, and the process is repeated from

10   block 404 until the base station determines that the
number of channels required to transmit the
communication signal at the modified data rate is
available within the communication system.

After the high data rate communication signal has

15   been transmitted at block 412, certain transmission
conditions detected at block 414 may cause the number of
channels utilized by the high data rate communication
signal to change. For example, the quality of the
signal may have changed, necessitating an increase or

20   decrease in the number of traffic channels used by the
communication signal. In another example, more traffic
channels may have become available so that it is
possible to transmit a modified-data rate communication
signal at the initially requested data rate. In a

25   further example, the mobile station may have reported a
new base station as a soft hand-off candidate, and the
new base station may not have available the number of
traffic channels required to transmit the communication
signal at its existing data rate. In a still further

30   example, the data rate of the communication signal
itself may vary.

In each case where changed conditions detected at
block 414 cause the number of traffic channels
transmitting the high data rate communication signal to

35   change, the data rate is modified in accordance with the

changed conditions at block **410**, and the above-outlined
steps are repeated from block **404**. In a hard hand-off
case, the switchover time of both a mobile station and a
base station to a new set of traffic channels may be

5    accounted for in the communication signal data stream,
so that no bits are lost in the transition. For
example, data transmission may be suspended during the
transition. In addition, a base station may send a
control message to a mobile station indicating the new

10   channel order for incoming data. A simple algorithm
that eliminates the need to communicate the data order
is to put the first bit group in the lowest numbered
traffic channel, the next group into the next lowest
traffic channel, and so on.

15        In the case where the data rate of the
communication signal itself varies, for example, during
a video transmission when there is no movement of the
video image or during an internet transmission when the
data arrives in bursts, traffic channels may be released

20   so that they are available for use by other
communications. Alternatively, extra bits may be added
to the communication to maintain the initially selected
number of traffic channels. A combination of reserving
some traffic channels and releasing others is also

25   possible. When the data rate of the communication
signal returns to its nominal rate, a number of traffic
channels equal to a number of released traffic channels
may be re-allocated to the communication signal.

          The arbitrary nature of channel assignment for a

30   high data rate communication signal according to the
method disclosed herein is significant in numerous
respects. For example, FIG. 6 illustrates a soft hand-
off operation for a high data rate communication signal
in a DS-CDMA communication system in accordance with a

35   preferred embodiment of the present invention.

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As shown, communication system **300** provides for simultaneous transmission of high data rate communication signal **20** to and from a mobile communication unit **12**, which may be a mobile station and

5    which includes a controller **13**, through both central communication unit A **14**, which may be a base station and which includes controller **15**, and central communication unit B **16**, which may be a base station and which also includes a controller **17**.

10   When communication signal **20** is being established between mobile station **12** and base station A **14**, signal **20** is transmitted over a group of traffic channels **500** chosen arbitrarily from a list of traffic channels **502** available for communication. In addition, mobile

15   station **12** is supplied with a list of base stations, including base station B **16**, which are most likely to be candidates for hand-off of the communication signal **20**. Mobile station **12** also searches continuously for other base stations (not shown) in the area and maintains a

20   list of all base station pilot signals (not shown) it receives which are above a certain signal strength threshold. This list of base stations created by mobile station **12** is transmitted to a mobile telephone switching office (MTSO) **18**, which includes base station

25   control capability, whenever it is requested, or whenever the list changes. MTSO **18** maintains a connection to the public switched telephone network (PSTN) **22**.

Upon command from MTSO **18** via base station A **14**,

30   mobile unit **12** begins tracking base station B **16**, so that communication signal **20** from mobile unit **12** is received by both base station A **14** and base station B **16**. Thus, base station B **16** must generally assign the same number of traffic channels to track communication

35   signal **20** from mobile station **12** as base station A **14**

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has assigned to communication signal **20**. Assuming base
station B **16** has a sufficient number of channels
available, communication signal **20** will almost certainly
be continued at its existing data rate after hand-off to
5   base station B **16**, because base station B **16** is able to
assign channels to the communication signal **20** from a
list **504** of its available channels. The assignment of
traffic channels at base station B **16** may also be
performed arbitrarily.

10      To ensure that traffic channels are time and data
synchronized at both base station A **14** and base station
B **16**, traffic channel pairing information is transmitted
via communication signal **20** from base station A **14** to
mobile station **12** before mobile station **12** begins
15   tracking base station B **16**. Traffic channel pairing may
be performed by pairing the lowest number traffic
channel utilized by one base station to the lowest
number traffic channel used by the other base station.

Base stations A **14** and B **16** forward communication
20   signal **20**, along with a quality index, to MTSO **18**. MTSO
**18** may terminate one of the dual linkages between mobile
station **12** and base station A **14** or base station B **16**
based on a comparison of the signals **20** received from
each base station **14**, **16**.

25      For example, the link between mobile station **12** and
base station B **16** may be severed by MTSO **18** if mobile
station **12** returns to an area surrounding base station A
**14**, the connection between mobile station **12** and base
station A **14** may be broken in favor of the connection
30   between mobile station **12** and base station B **16** if
mobile station **12** travels closer to base station B **16**,
or MTSO **18** may order mobile station **12** to begin tracking
another base station entirely. Thus, alternate base
stations simply take turns servicing a mobile station--

when one base station is out of range, another joins the group serving that mobile station.

The principles of the present invention which apply to cellular-based communication systems also apply to other types of communication systems, including but not limited to personal communication systems, trunked systems, satellite communication systems and data networks. Likewise, the principles of the present invention which apply to all types of radio frequency channels also apply to other types of communication channels, such as RF signaling channels, electronic data buses, wireline channels, optical fiber links and satellite links.

It will further be apparent that other and further forms of the invention may be devised without departing from the spirit and scope of the appended claims and their equivalents, and it will be understood that this invention is not to be limited to the specific embodiments shown.

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## Claims

We claim:

1.      A method for transmitting a communication
signal having a data rate over a plurality of spread
5    spectrum traffic channels, comprising:

(a)    determining a first number of traffic channels
required to transmit the communication signal at the
data rate;

(b)    determining a second number of traffic
10    channels available for transmitting the communication
signal;

(c)    comparing the first number of traffic channels
to the second number of traffic channels;

(d)    selecting, in response to the comparison of
15    the first number of traffic channels to the second
number of traffic channels, a first traffic channel for
transmitting a first portion of the communication
signal, the first traffic channel being selected from
the second number of traffic channels available for
20    transmitting the communication signal; and

(e)    selecting a second traffic channel for
transmitting a second portion of the communication
signal, the second traffic channel being selected from
the second number of traffic channels available for
25    transmitting the communication signal, the selection of
the first traffic channel being non deterministic of the
selection of the second traffic channel.

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2. The method according to claim 1, further comprising the steps of:

(f) spreading the first portion of the
5  communication signal with a first code;

(g) spreading the second portion of the communication signal with a second code, the first and second codes being substantially orthogonal;

(h) combining the first portion of the
10  communication signal and the second portion of the communication signal to form a modulated communication signal; and

(i) transmitting the modulated communication signal.

15

3. The method according to claim 1, further comprising the steps of:

modifying the data rate of the communication signal when the first number of traffic channels is greater
20  than the second number of traffic channels; and

repeating steps (a) through (e).

4. The method according to claim 1, further comprising the steps of:

25  modifying the data rate of the communication signal if a transmission condition of the communication signal changes; and

repeating steps (b) through (e).

30  5. The method according to claim 4, wherein the transmission condition of the communication signal changes based on a number of bits of the communication signal which are available for transmission.

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6.    The method according to claim 4, wherein the transmission condition of the communication signal changes based on a quality of the communication signal.

5          7.    The method according to claim 1, wherein the first traffic channel is selected arbitrarily.


8.    The method according to claim 1, wherein the second traffic channel is selected arbitrarily.

10
9.    A spread spectrum communication system comprising:
          a first central communication unit responsive to a mobile communication unit over a first plurality of
15    traffic channels; and
          a first controller associated with the first central communication unit operable for assigning a first group of traffic channels for transmitting and receiving a communication signal, the first group of
20    traffic channels comprising a first traffic channel and a second traffic channel chosen from the first plurality of traffic channels, the first traffic channel being non deterministic of the second traffic channel.


25          10.    A method for receiving a modulated communication signal transmitted over a plurality of traffic channels in a spread spectrum communication system, each of the plurality of traffic channels being associated with a code having a plurality of groups of
30    chips, the method comprising:
          (a)    inputting the modulated communication signal to a decoder representative of a number of logical rows of adders, the number of logical rows of adders being larger than a number of traffic channels in the
35    plurality of traffic channels;

(b)    demodulating the modulated communication
signal based on a first group of chips of a first code
associated with at least one of the plurality of traffic
channels, to form a first partially demodulated

5    communication signal;

(c)    demodulating the modulated communication
signal based on a second group of chips of a second code
associated with at least one of the plurality of traffic
channels, to form a second partially demodulated
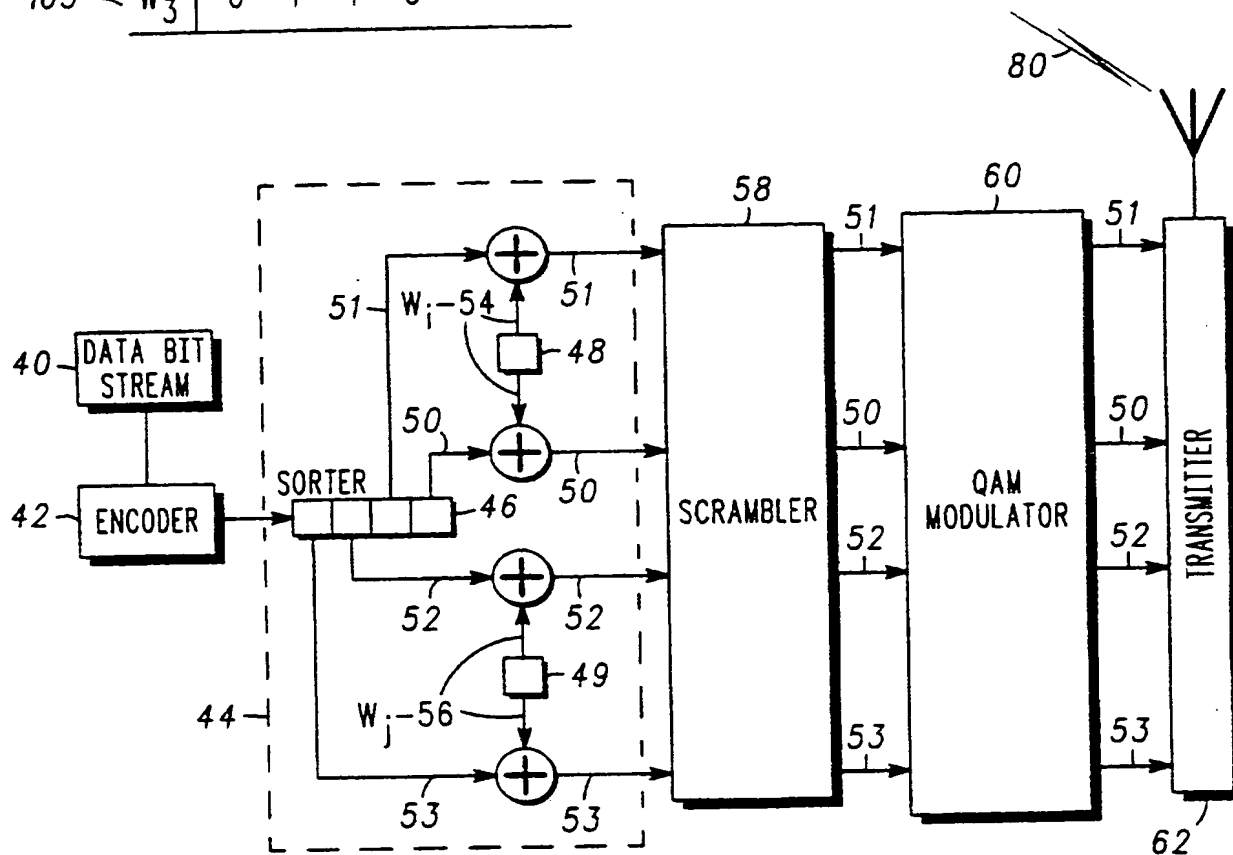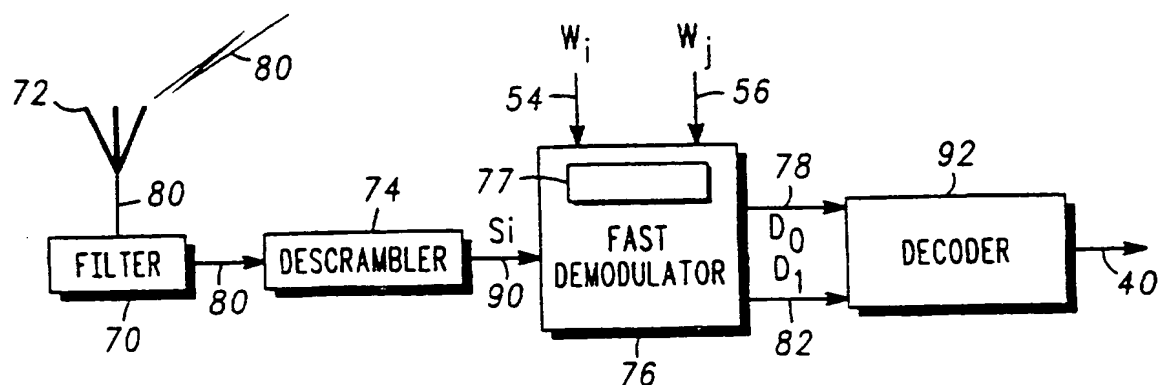
10    communication signal; and

(d)    combining the first partially demodulated
communication signal with the second partially
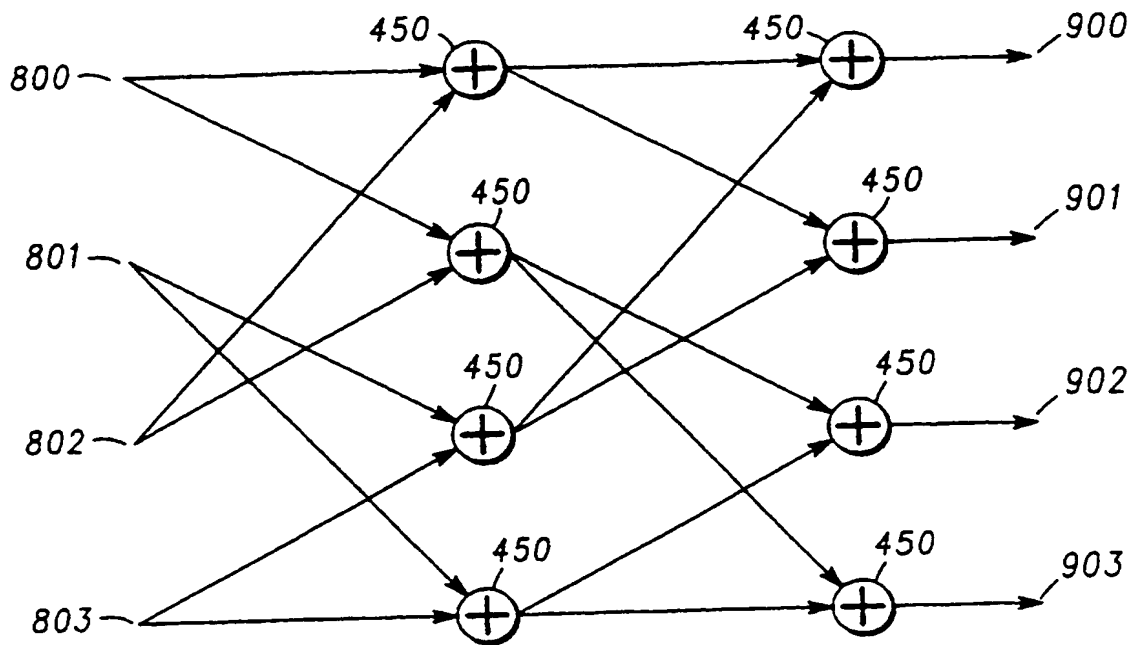demodulated communication signal.

1/3



*F I G . 1*
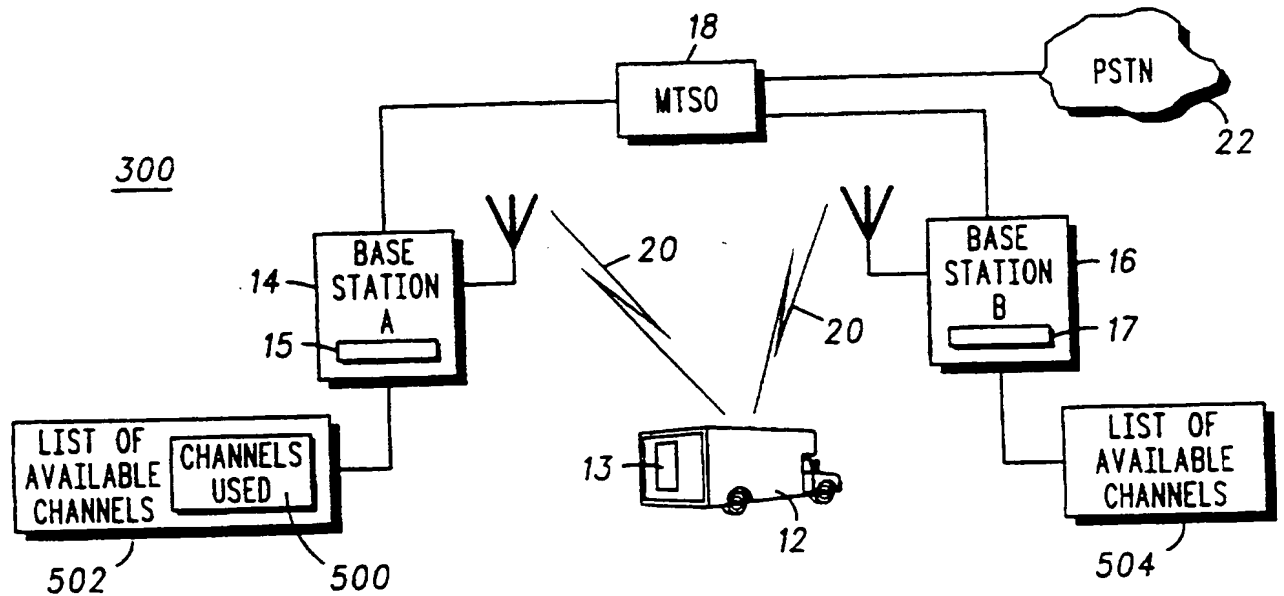
−PRIOR ART−



*F I G . 2*



*F I G . 3*

F I G . 4



F I G . 6

REQUEST FOR HIGH DATA RATE
COMMUNICATION ——400

DETERMINE REQUIRED
NUMBER OF TRAFFIC CHANNELS ——404

TRAFFIC
CHANNELS AVAILABLE
? ——406

NO

YES

SELECT TRAFFIC
CHANNELS ——408

TRANSMIT HIGH DATA RATE
COMMUNICATION SIGNAL ——412

NEW
TRANSMISSION CONDITIONS
? ——414

NO

YES

MODIFY DATA RATE ——410

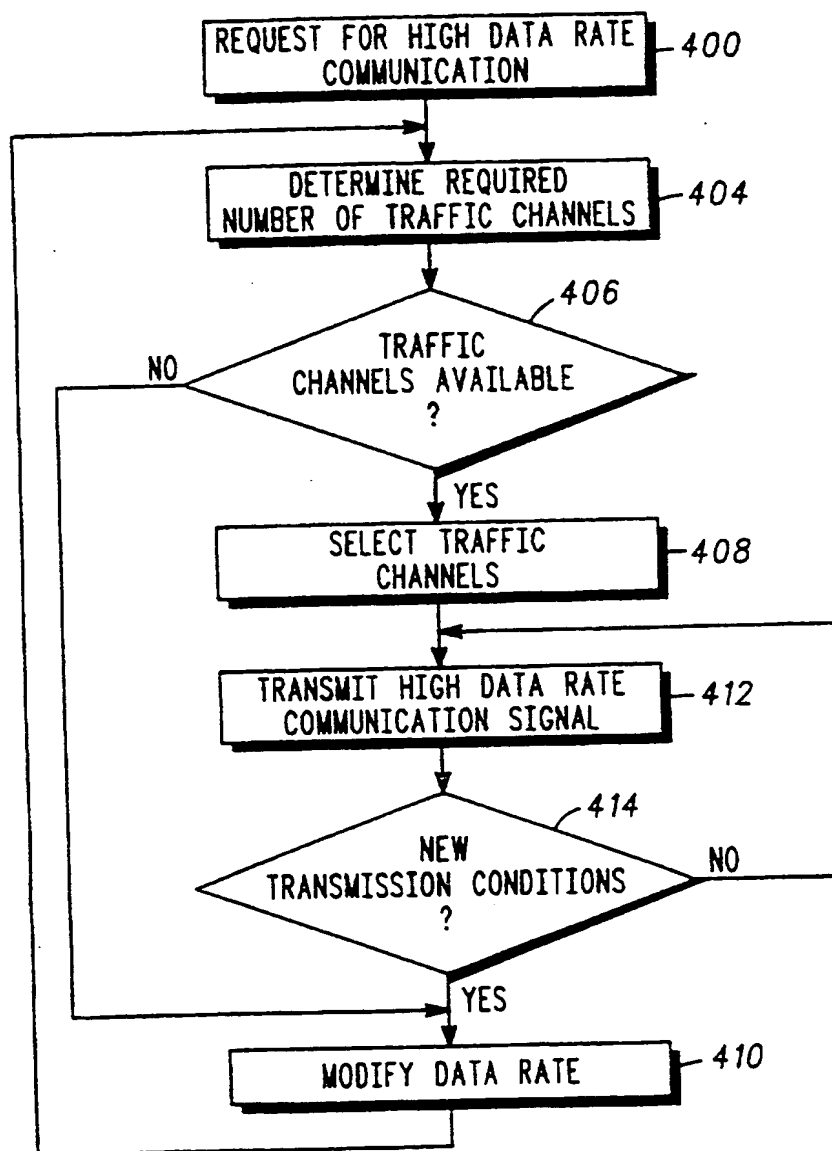*FIG.5*

# INTERNATIONAL SEARCH REPORT

International application No.

PCT/US96/19016

## A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :H04J 13/04; H04B 1/707
US CL :375/206; 370/342

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 375/200, 205, 206; 370/208, 209, 335, 342, 441, 479

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Please See Extra Sheet.

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|-----------------------------------------------------------------------------------|----------------------|
| A | US 3,518,547 A (FILIPOWSKY) 30 June 1970, entire document. | 1-10 |
| A | US 5,442,625 A (GITLIN et al) 15 August 1995, entire document. | 1-10 |
| A, E | US 5,583,851 A (KATO et al) 10 December 1996, entire document. | 1-10 |

☐ Further documents are listed in the continuation of Box C.  ☐ See patent family annex.

| | Special categories of cited documents: | "T" | later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention |
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| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 06 FEBRUARY 1997 | 11 MAR 1997 |
| Name and mailing address of the ISA/US<br>Commissioner of Patents and Trademarks<br>Box PCT<br>Washington, D.C. 20231<br>Facsimile No. (703) 305-3230 | Authorized officer<br>JEFFREY W. GLUCK<br>Telephone No. (703) 308-5462 |

Form PCT/ISA/210 (second sheet)(July 1992)*